# New VLBA Identifications of Compact Symmetric Objects

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**Abstract**

The class of radio sources known as Compact Symmetric Objects (CSOs) is of particular interest in the study of the evolution of radio galaxies. CSOs are thought to be young (probably $\sim 10^4$ years), and a very high fraction of them exhibit H I absorption toward the central parsecs. The H I, which is thought to be part of a circumnuclear torus of accreting gas, can be observed using the VLBA with high enough angular resolution to map the velocity field of the gas. This velocity field provides new information on the accretion process in the central engines of these young sources.

We have identified 9 new CSOs from radio continuum observations for the VLBA Calibrator Survey, increasing the number of known CSOs by almost 50%.

## 1 Introduction

Compact Symmetric Objects are distinguished from other classes of compact radio sources by their striking degree of symmetry. This is due to the fact that CSOs tend to lie close to the plane of the sky, and so relativistic beaming plays a very minor role in their observed properties. They usually have well-defined lobes and edge-brightened hotspots on either side of an active core, often exhibiting an "S" shaped symmetry (Taylor et al. 1996). CSOs are $< 1$ kpc in size, and usually have high intrinsic radio luminosities and low levels of polarization. Their small physical size is thought to be attributable to the youth of the sources, rather than to confinement by a dense medium (Readhead et al. 1996a). It is likely that these sources will evolve into Compact Steep Spectrum sources, and then into the large classical doubles (Readhead et al.

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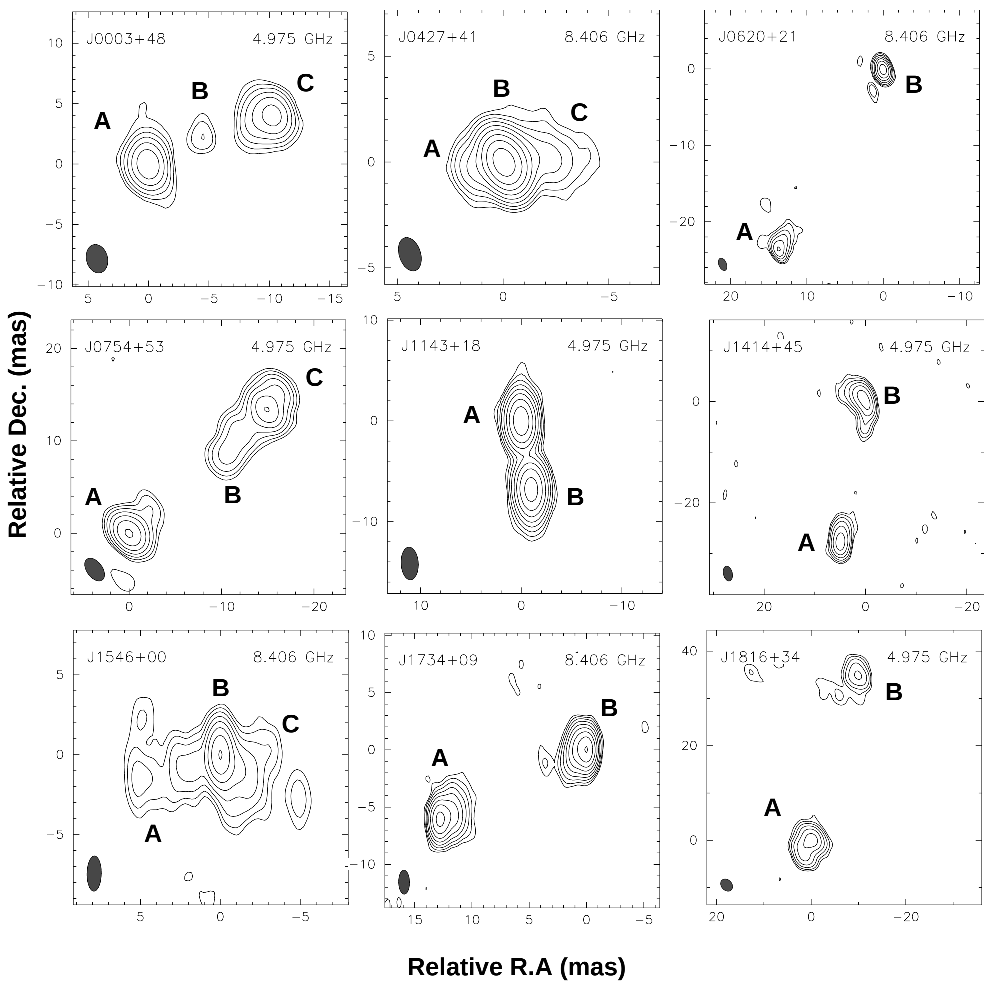


Fig. 1. Continuum images of the nine most promising CSO candidates.

1996b). The advance speeds of the hotspots have been measured for a few CSOs, using data taken over $\sim$10 years (Owsianik & Conway 1998), and yield kinematic ages of $10^3$ to $10^4$ years.

One of the most important properties of CSOs for studies of galaxy evolution is the very high rate of detection of H I absorption lines (Peck et al. 1999). In many cases, this H I appears to be part of a circumnuclear structure which is thought to be feeding and obscuring the central engine (Peck, Taylor & Conway 1999). For this reason, we have undertaken a survey to identify new CSOs from the VLBA Calibrator Survey (VCS) (http://magnolia.nrao.edu/vlba_calib/, Peck & Beasley 1997).

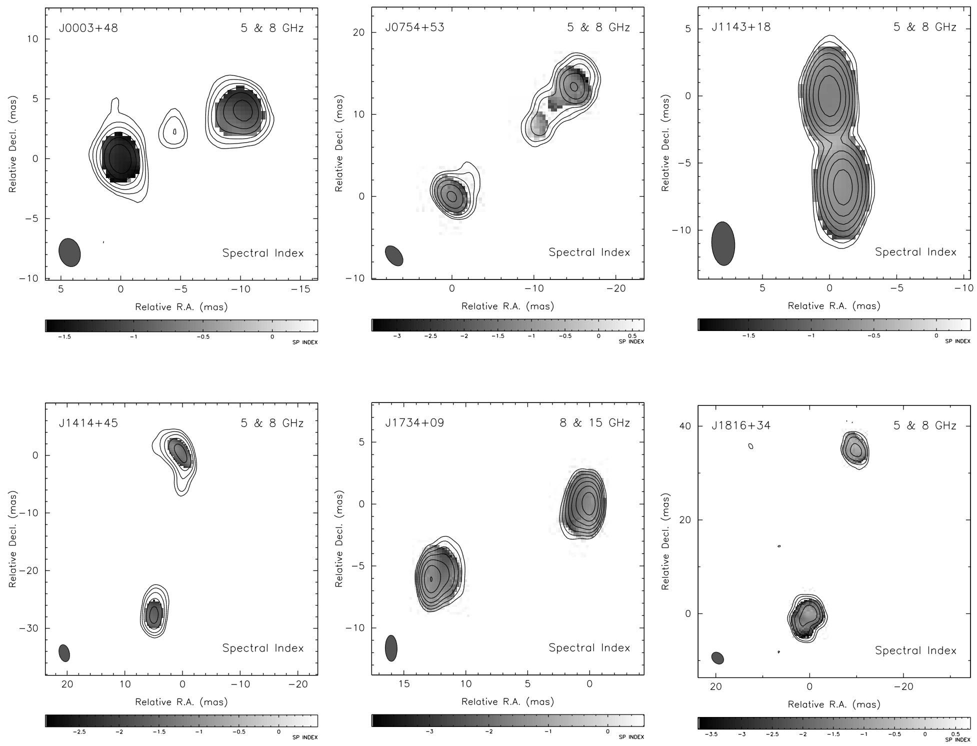


Fig. 2. Spectral Index distributions for six of the new CSOs.

## 2 Results

The sources in this study were selected from images of positive declination sources in the VCS. Negative dec. sources will be added at a later date. The CSO candidates were identified based on at least one of the following criteria: a) double structure at 2 GHz, 8 GHz or both, where "double structure" is considered to mean having two distinct components with an intensity ratio $< 10 : 1$; b) a strong central component with possible extended structure on both sides at one or both frequencies; c) possible edge-brightening of one or more components.

Positive classification of CSOs requires multifrequency observations in order to identify the expected steep spectrum hotspots and a flat or inverted spectrum core. The $\sim$40 selected sources were observed with the VLBA at 2 frequencies in addition to the discovery frequency. Details of these follow-up observations are reported in Peck & Taylor (1999).

Images of the most promising CSO candidates are shown in Figure 1. The frequency of the image shown is indicated in the upper right corner of each plot, and the beam is displayed in the lower left. Table 1 lists the flux densities of

Table 1
Fluxes and Spectral Indices of CSOs

| Source | Comp. | $S_5$ | $S_{8.4}$ | $S_{15}$ | $\alpha^{5}_{8.4}$ | $\alpha^{8.4}_{15}$ |
|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| J0003+4807 | A | 70.6 | 36.9 | ... | -1.24 | ... |
| | B | 3.5 | 3.4 | ... | -0.06 | ... |
| | C | 66.0 | 40.3 | ... | -0.94 | ... |
| J0427+4133 | A | ... | 32.7 | 22.0 | ... | -1.46 |
| | B | ... | 588.9 | 406.0 | ... | -0.63 |
| | C | ... | 28.7 | 13.9 | ... | -1.23 |
| J0620+2102 | A | 478.4 | 77.2 | ... | ... | ... |
| | B | 400.0 | 148.4 | ... | ... | ... |
| J0754+5324 | A | 76.1 | 29.4 | ... | -1.81 | ... |
| | B | 26.7 | 10.2 | ... | -0.52 | ... |
| | C | 79.6 | 34.2 | ... | -1.61 | ... |
| J1143+1834 | A | 180.7 | 121.2 | ... | -0.76 | ... |
| | B | 159.8 | 112.7 | ... | -0.67 | ... |
| J1414+4554 | A | 76.1 | 34.2 | ... | -1.52 | ... |
| | B | 97.8 | 41.9 | ... | -1.62 | ... |
| J1546+0026 | A | ... | 94.2 | 60.7 | ... | -0.75 |
| | B | ... | 354.0 | 242.9 | ... | -0.64 |
| | C | ... | 87.8 | 71.7 | ... | -0.34 |
| J1734+0926 | A | ... | 162.4 | 66.7 | ... | -1.51 |
| | B | ... | 238.8 | 97.2 | ... | -1.53 |
| J1816+3457 | A | 196.8 | 74.4 | ... | -1.85 | ... |
| | B | 75.9 | 27.7 | ... | -1.92 | ... |

each component at all frequencies at which follow-up observations were made. Columns 6 and 7 list the spectral indices of the components. The spectral index distribution for sources in which such an image was feasible are shown in Figure 2.

## 3 Future Work

VLBA imaging of H I absorption in CSOs provides an unparalleled means of determining the kinematics of neutral gas within 100 pc of an active nucleus (Peck, Taylor & Conway 1999, Taylor et al. 1999). VLBA imaging of free-free absorption in CSOs is also possible, and allows us to probe the region of ionized gas surrounding the central engine (Peck, Taylor & Conway 1999). A complete sample of such sources will yield unique information about accretion processes and the fueling mechanism by which these young radio galaxies might evolve into much larger FRII type sources.

## References

Owsianik, I. & Conway, J. E. 1998, A&A, 337, 69, astro-ph/9712062

Peck, A. B. & Taylor, G. B. 1999, ApJ, *submitted*

Peck, A. B., Taylor, G. B., Fassnacht, C. D., Readhead, A. C. S., & Vermeulen, R. C. 1999, ApJ, *submitted*

Peck, A. B., Taylor, G. B., & Conway, J. E. 1999, ApJ, 521, 103, astro-ph/9811386

Peck, A. B. & Beasley, A. J. 1998, in *IAU Colloquium 164: Radio Emission from Galactic and Extragalactic Compact Sources* eds. J. A. Zensus, G. B. Taylor and J. M. Wrobel (PASP: San Francisco), Vol. 144, p. 155

Readhead, A. C. S., Taylor, G. B., Xu, W., Pearson, T. J., Wilkinson, P. N. and Polatidis, A. G. 1996a, ApJ, 460, 612

Readhead, A. C. S., Taylor, G. B., Pearson, T. J. and Wilkinson, P. N. 1996b, ApJ 460, 634

Taylor, G. B., O'Dea, C. P., Peck, A. B. & Koekemoer, A. M. 1999, ApJ, 512, L27, astro-ph/9811343

Taylor, G. B., Readhead, A. C. S. and Pearson, T. J. 1996, ApJ, 463, 95